# United States Patent [19]

**Timbs**

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[45] **Jan. 27, 1976**


[54] **VARIABLE SPEED DRIVE FOR BICYCLES AND THE LIKE**


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**Related U.S. Application Data**

[63] Continuation of Ser. No. 428,029, Dec. 26, 1973, abandoned.

[52] **U.S. Cl.** ..... **74/740;** 74/689; 74/750 B

[51] **Int. Cl.²** ..... **F16H 37/06**

[58] **Field of Search** ..... 74/750 B, 689, 690, 691, 74/681, 686, 687, 688, 740



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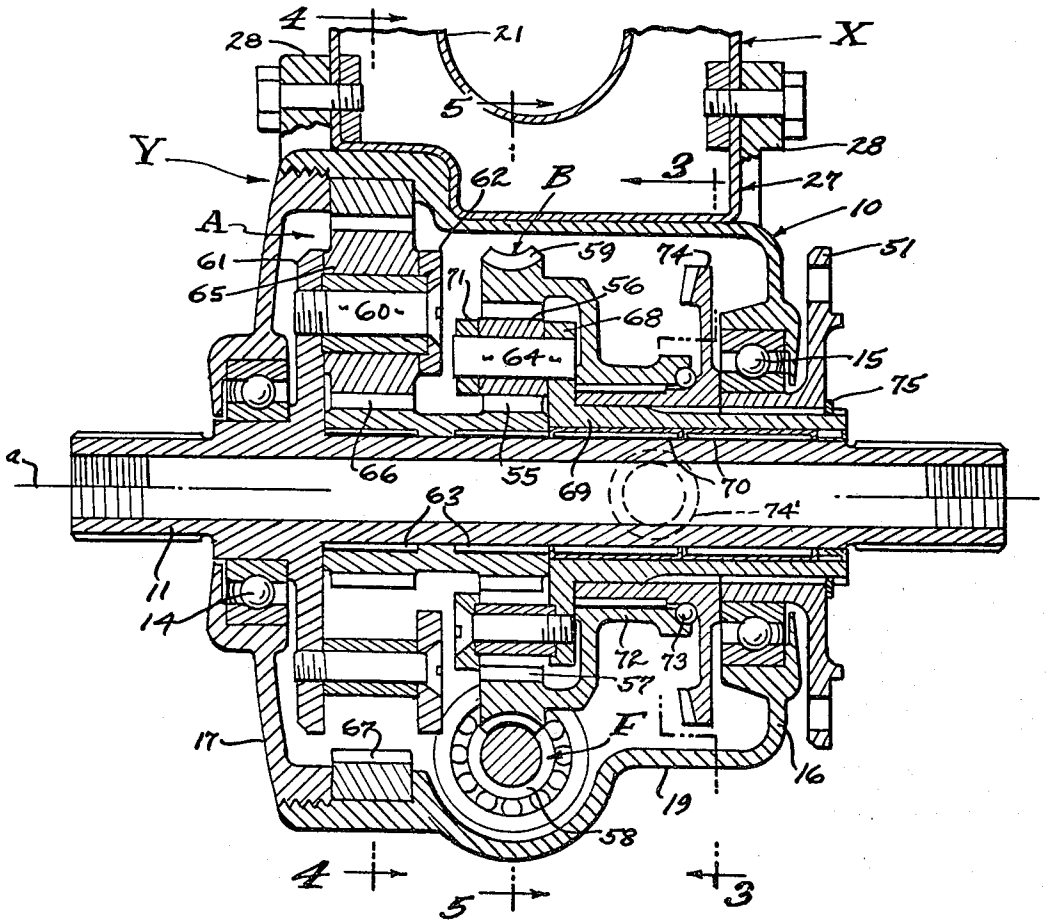
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[57] **ABSTRACT**

A variable speed "stiff-hub " drive adapted particularly to bicycles and comprised of a constant mesh infinitely variable gearing with an integral input crank shaft projecting axially from opposite ends of an enclosing case, with a drive sprocket at one side of the case and coaxially disposed over one of said crank shaft ends, and having a control means which operates in conjunction with a single lever which also comprises the braking force actuator.


**11 Claims, 8 Drawing Figures**



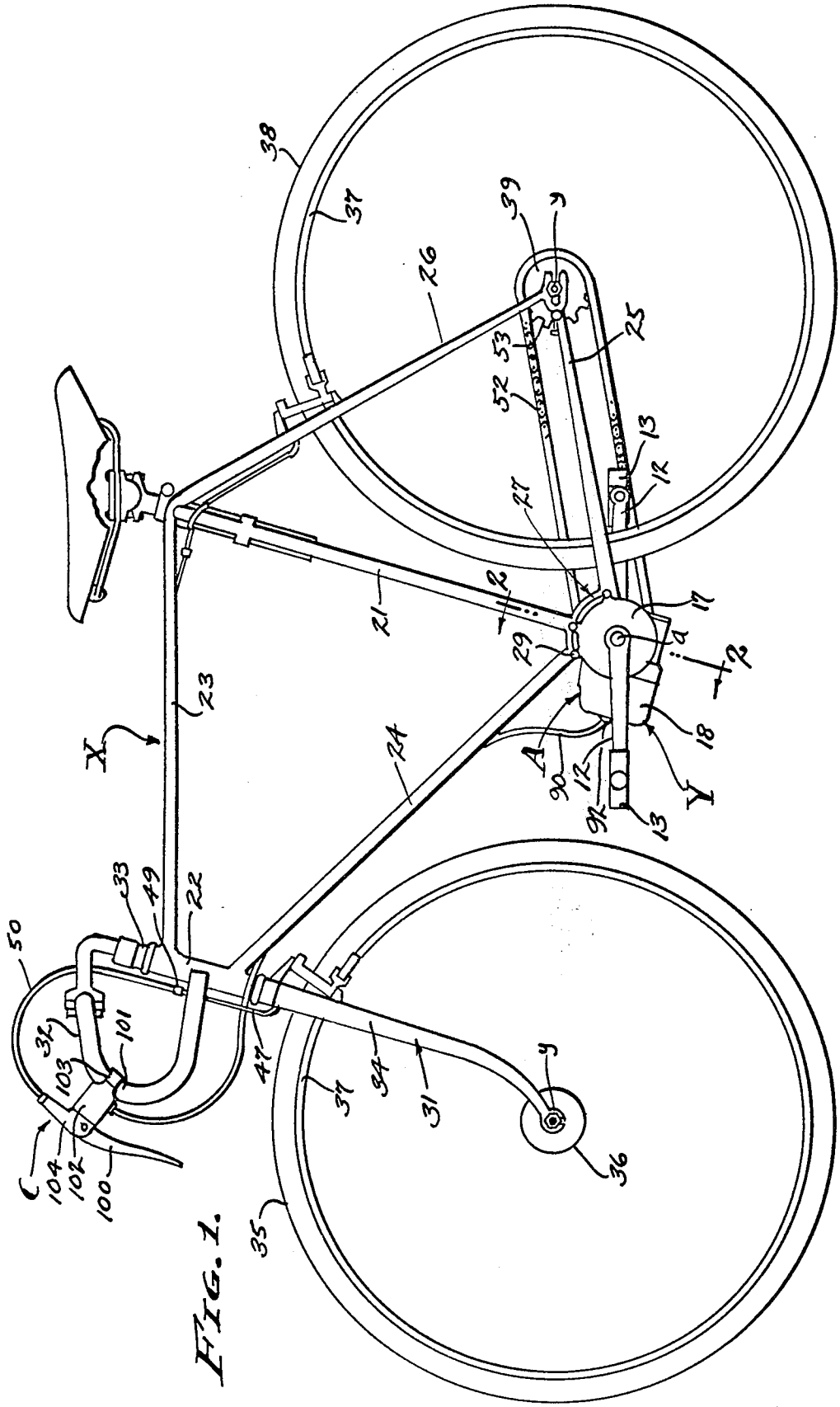

38
37
39
26
25
53
52
13
12
27
21
29
17
18
23
24
22
33
49
50
101
103
104
102
100
47
34
31
36
35
X
Y
A

FIG. 1.

FIG. 2.

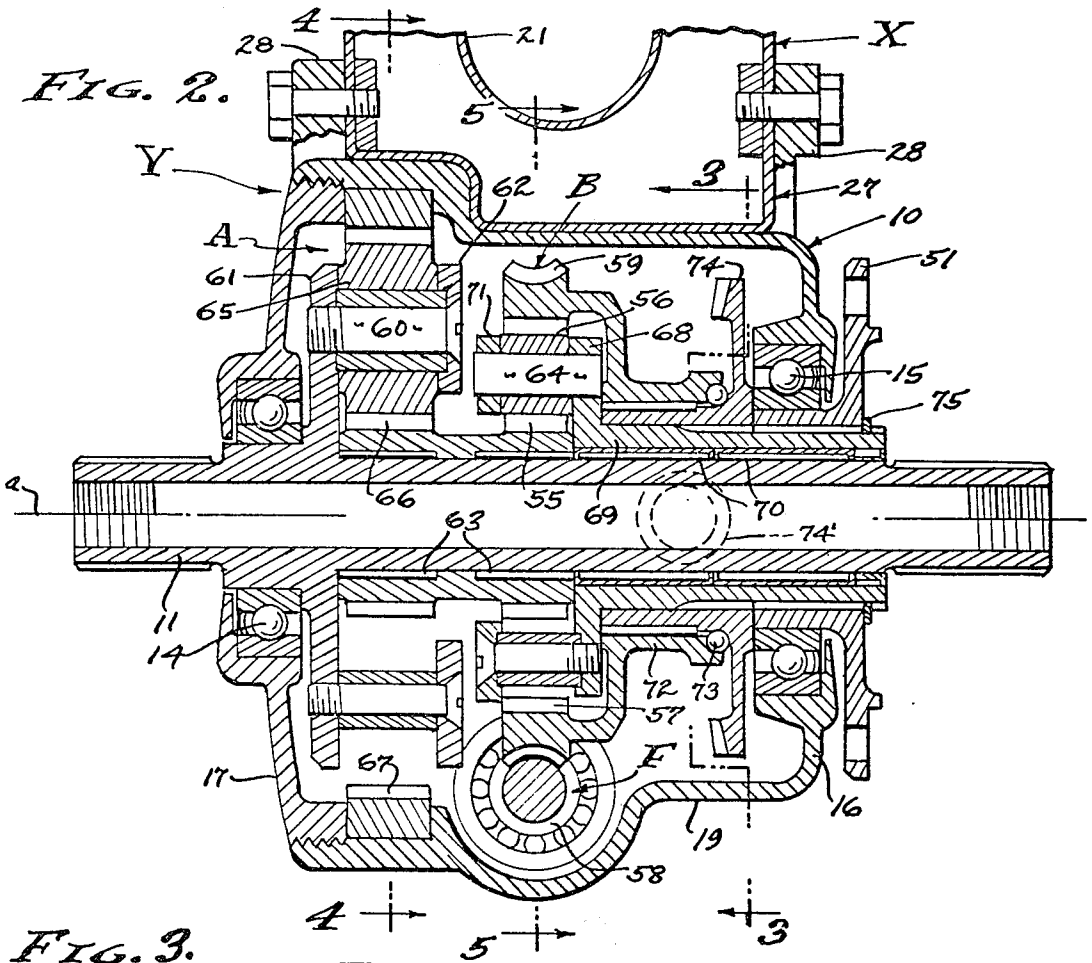

4
28
21
X
5
Y
62
B
3
27
28
A
10
61
59
74
51
65
60
71
56
68
64
15
75
66
55
69
70
74'
63
11
14
72
73
57
67
E
17
16
19
58
4
5
3

FIG. 3.

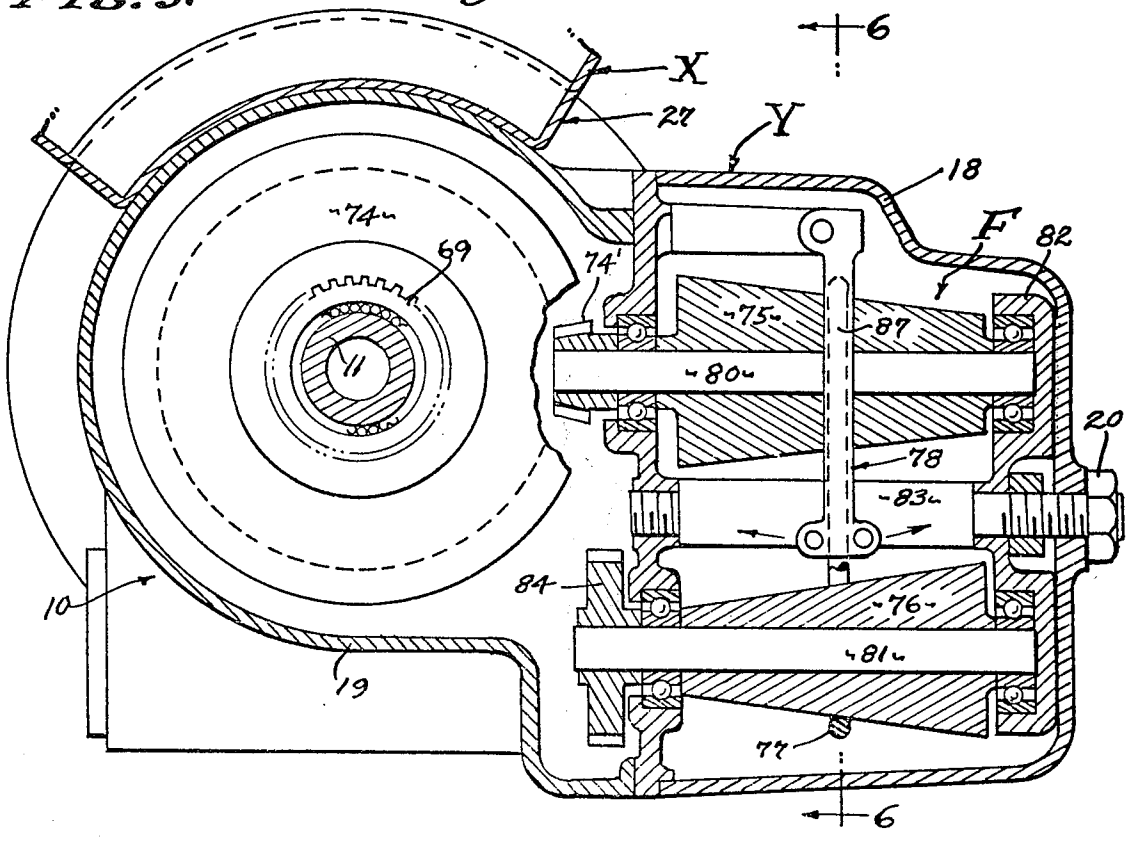

6
X
27
Y
18
74
69
74'
F
82
75
87
80
20
78
83
10
84
76
81
19
77
6

FIG. 4.
STAGE I

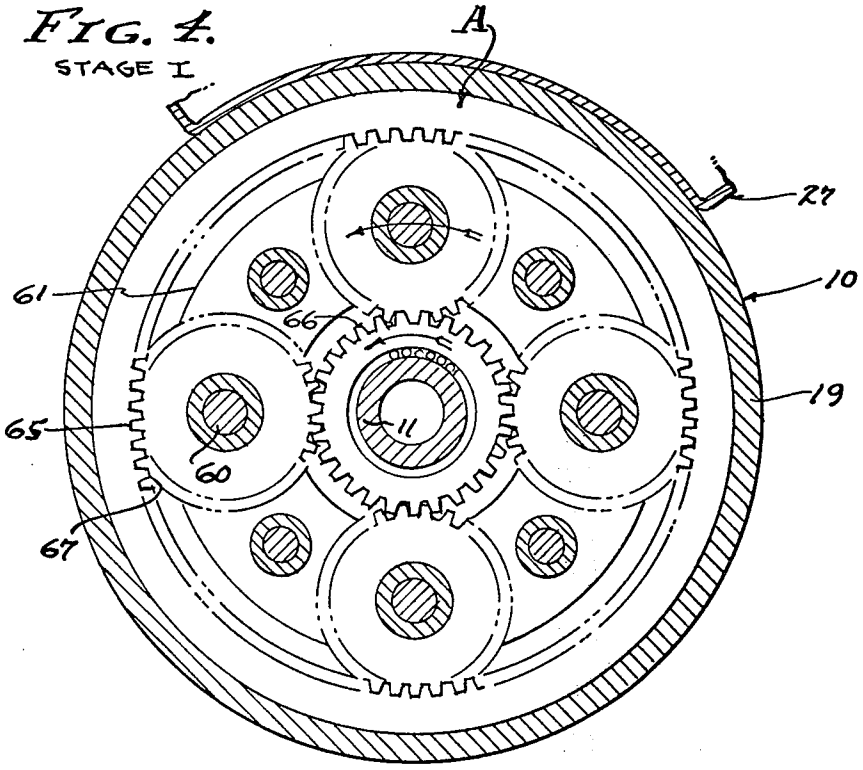



FIG. 5.
STAGE II

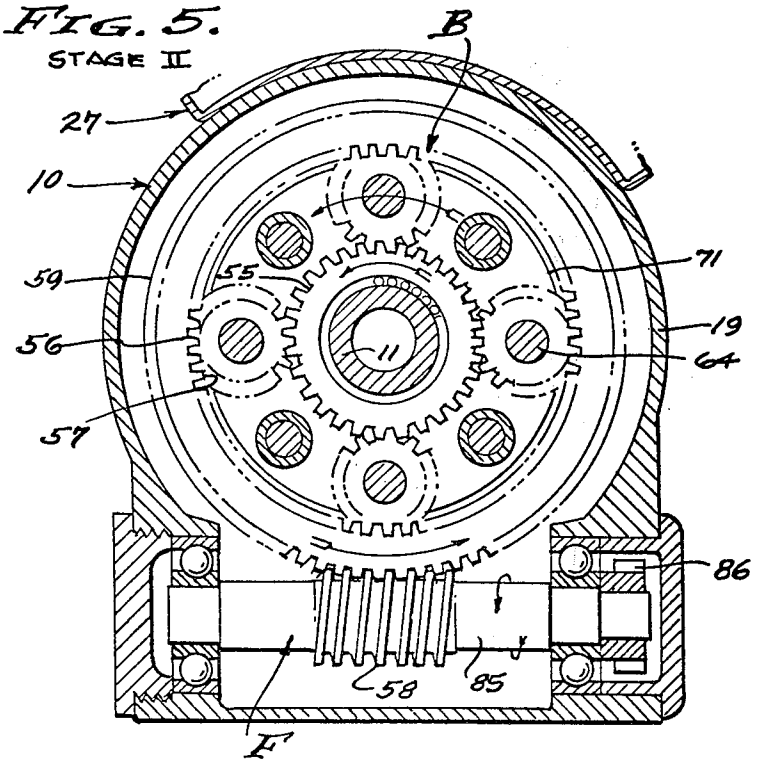


FIG. 6.

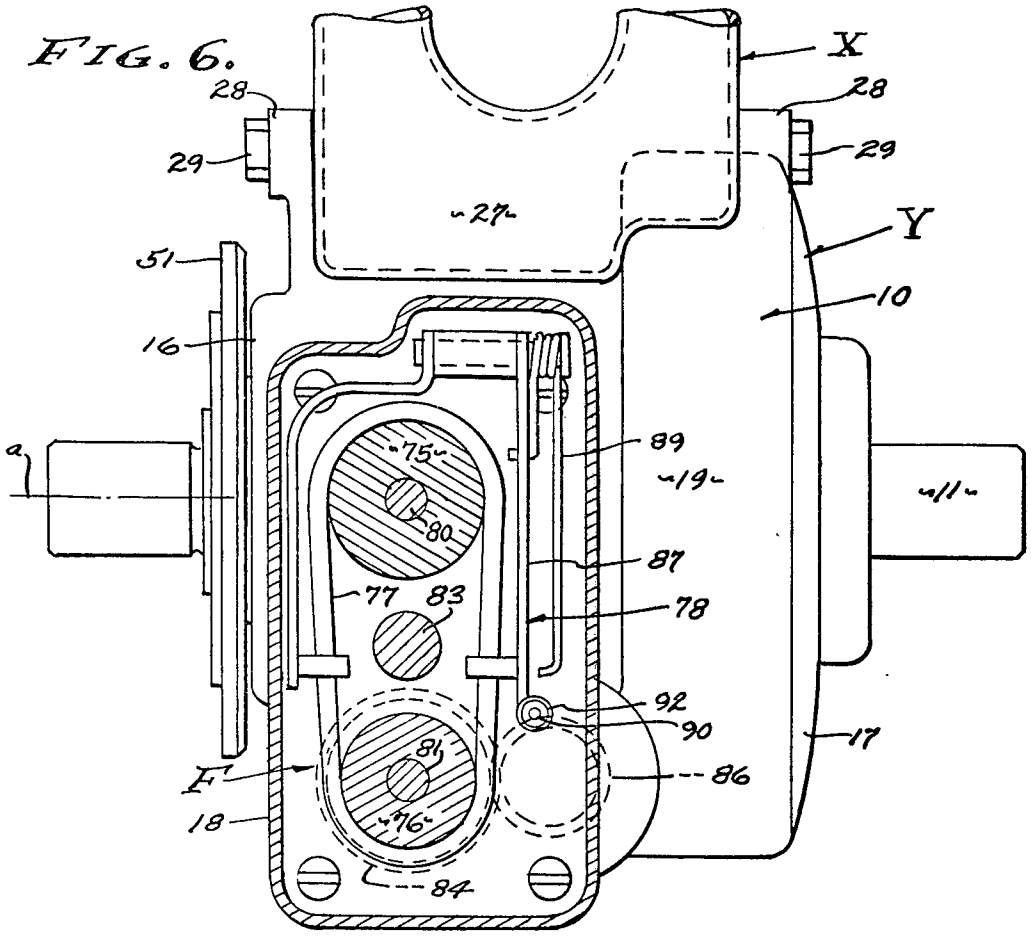



FIG. 7.

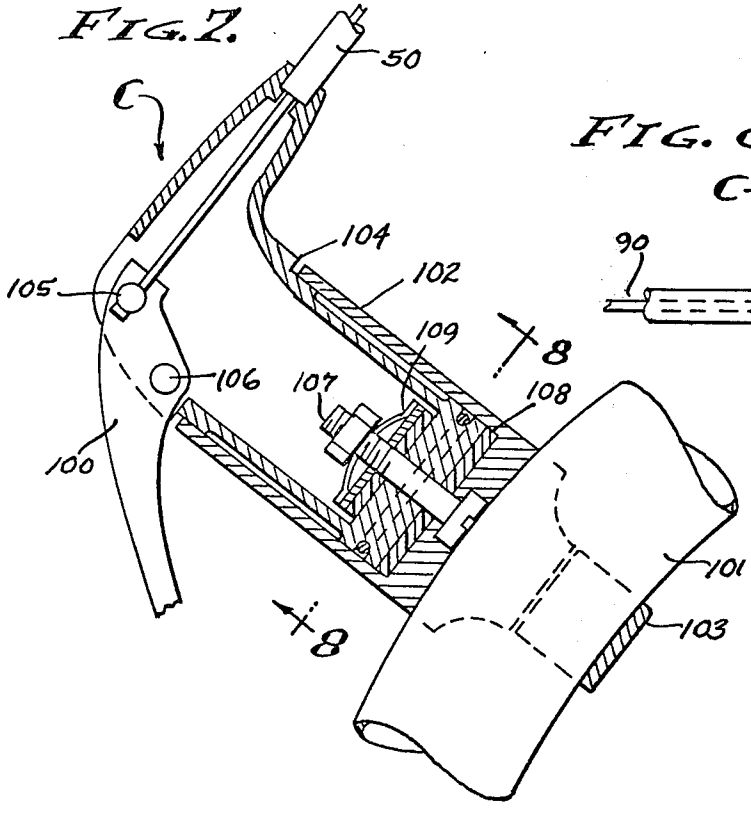
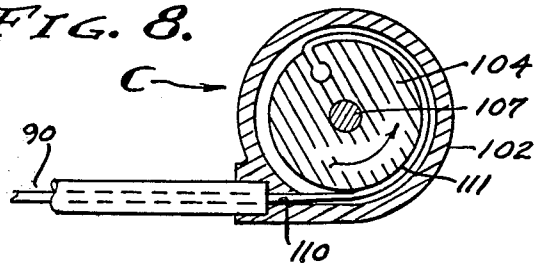



FIG. 8.



# VARIABLE SPEED DRIVE FOR BICYCLES AND THE LIKE

This is a continuation of application Ser. No. 428,029, filed Dec. 26, 1973, entitled Vehicle Transmission and Brake now abandoned.

## BACKGROUND

It is a general object of this invention to provide vehicular transportation capable of moving varied loads at varied speeds and under varied conditions, utilizing a prime mover having capabilities that require mechanical advantage, particularly when human powers are relied upon. Although the concepts herein disclosed are applicable to engine or motor powered vehicles and/or like devices, it is the human powered vehicle and/or device such as a bicycle in which this invention is advantageously embodied as hereinafter disclosed. Working pressure available from human power is substantial while continued muscular effort through the movement of human limbs is limited, and therefore efficient mechanical advantage is much to be desired, and it is to these ends that I have provided this improved and cooperatively related vehicle, transmission and braking.

Referring to the motivating power necessary to accelerate and to propel bicycles and the like, especially human powered vehicles, a multi-speed transmission is commonly employed, but limited to certain spaced gear ratios. Derailleur chain and sprocket gearing is commonly employed, and there are geared hubs, for implementing speed ratio changes between the foot pedal operated crank and the supporting drive wheel. The commonly accepted type of gear changer is the Derailleur type, with its speed ratio limitations and complexities which not only encumber the vehicle but which are vulnerable to damage. Therefore, it is an object of this invention to eliminate gear ratio limitations and to provide infinitely variable gear ratios within the range required. With the present invention, a variable ratio transmission is provided for changing the angular velocity from an input shaft to an output shaft; and in the particular case illustrated, to increase angular velocity from a bicycle crank shaft to a drive sprocket that rotates a drive wheel (the rear wheel).

Variable ratio transmissions of the prior art have not been positive, and in one way or another rely upon frictional engagement between the drive and driven members; reference being made to cone or V-belt pulley drives, disc and roller drives. Also, variable ratio transmissions exist in the form of both hydraulic and electric apparatus wherein current flow is controlling, but not absolutely positive in every application. On the contrary, meshed gear engagement is positive and it is therefore an object of this invention to provide positive in-mesh infinitely variable ratio transmission of rotative power having the advantages of direct and positive gear engagement between an input shaft and an output shaft. With the present invention, there is a constant mesh ratio changer and variable speed feedback to an element thereof adding to or subtracting from the output velocity, and in the preferred embodiment there are first and second stages of gearing and there is a variable speed feedback into one stage to add or substract angular velocity as may be required. A feature of the transmission is the feedback through non-reversible gearing which substantially reduces the torque requirement of the infinitely variable speed control means that governs the input-output speed ratio.



Transmissions involving gears and controls therefor are most often weighty and space consuming, it being an object of this invention to provide a variable ratio transmission of the character thus far referred to that is small and compact, and consequently of relatively light weight. The bicycle, for which the embodiment herein disclosed is designed, is a light weight competition cycle, in which case the input torque on the crank shaft is quite high. Therefore, it is also an object to provide a durable gearing that will withstand any and all mechanical pressures likely to be imposed thereon. In practice, the first and second gearing stages are of the planetary type with multiple pinions having wide faced toothed engagement, while the speed regulating control means includes a non-reversible worm and wheel feedback drive into the second stage gearing operating at lower torque value than the first stage gearing. Antifriction bearings are used exclusively in the journaling of all torque transmitting and/or higher velocity elements.

The independent controllability of prior art bicycle transmissions and braking has involved separate manual controls, the former requiring selective positioning and the latter requiring forceful actuation. It is an object of this invention to combine the independent controllability of these two control functions into one control means by which both selective positioning and forceful actuation are manually applied. As will be described, the controlling means comprises a lever having distinct modes of actuation, one whereby it is rotatively positioned to effect selectivity of the variable output ratio of the transmission hereinabove referred to, and one whereby it is forcibly displaced to effect actuation of the brake.

The usual hanger assembly of the conventional bicycle is replaced in the present invention, it being an object to provide a frame adapted to accept the transmission of the character hereinabove referred to. In practice, the said transmission and its control means are combined in a casing adapted to be disassembled for accessibility, and for removal and replacement.

## DRAWINGS

The various objects and features of this invention will be fully understood from the following detailed description of the typical preferred form and application thereof, throughout which description reference is made to the accompanying drawings, in which:

FIG. **1** is a side elevation of the vehicle transmission and brake of the present invention.

FIG. **2** is an enlarged detailed sectional view of the transmission taken as indicated by line **2—2** on FIG. **1.**

FIGS. **3, 4,** and **5** are sectional views taken as indicated by lines **3—3, 4—4,** and **5—5** on FIG. **2.**

FIG. **6** is a sectional view of the variable speed feedback drive which characterizes the present invention, being a view taken as indicated by line **6—6** on FIG. **3.**

FIG. **7** is an enlarged fragmentary and sectioned view of the single control means (removed from FIG. **1**) provided for braking and to condition the transmission.

FIG. **8** is a sectional view taken as indicated by line **8—8** on FIG. **7.**

## PREFERRED EMBODIMENT

The present invention involves, generally, a vehicle X and transmission Y and brake concept cooperatively

combined as a bicycle adapted to be powered by a rider for motivation. The prerequisites of a high performance bicycle are light weight, strength, and a wide transmission range; and it is in each of these that the present invention provides improvements. Firstly, the constant mesh infinitely variable speed transmission Y is characterized by a casing of a type and configuration unprecedented in cycle frames, and in this respect the vehicle X is provided with a frame for the replaceable combining of said transmission Y therewith. Secondly, the variable speed controllability of the transmission Y is effected by control means C that simultaneously controls the independent actuation of the brake.

## TRANSMISSION-FRAME

The vehicle X involves a frame to which the case of the transmission Y is removeably and/or replaceably secured. As will be hereinafter described, the transmission Y involves several interrelated gear means and a variable speed feedback, in which case there is a sizeable gear case **10** disposed on a transverse horizontal axis on which the crank shaft **11** projects therethrough to carry a pair of diametric crank arms **12** at its opposite projecting ends. There are pedals **13** at the working ends of the arms for conventional application of force by a rider. The interior of case **10** is to accommodate the said several gear means, there being carrier bearings **14** and **15** at axially opposite ends of the case to carry the crank shaft **11** through members telescopically engaged thereover; one end of the case being permanently closed by a wall **16** and the other end by a removeable plate **17.** The carrier bearings **14** and **15** are journaled in the wall **16** and plate **17** respectively. The interior of the case **10** is open radially for the accessible installation of the variable feedback, and over which there is a removeable cover **18.** In practice, the variable feedback and its cover **18** are horizontally disposed to project forwardly, the cover **18** being detachably secured to the case housing **19** by means of a screw fastener **20.**

In accordance with this invention, the case **10** hereinabove described is fastened into the frame of the vehicle X so that the one structurally complements the other. Although the frame type or configuration can vary, the preferred "diamond" frame is employed as shown, involving a center post **21,** a head **22,** upper and lower rails **23** and **24** extending between the upper and lower extremities of the post and head respectively, and convergent lower and rear forks **25** and **26** extending rearwardly from the bottom and top extremities of the center post respectively. The joinder of the bottom and lower extremities of the post **21,** lower rail **24** and lower fork **25** is by means of a saddle **27** having a seat complementary to the exterior of housing **19** of the transmission case **10.** In practice, the seat is an arcuate quadrant centered about the axis *a* of the crank shaft **11,** there being widely spaced and parallel flanges **28** embracing the opposite faces of the saddle and fastened thereto by screw fasteners **29** in shear, as is clearly shown. Correspondingly, each of the frame elements **21, 24** and **25** are comprised of monocoque tubes and by joinder at the head **22** and by joinder into the saddle **27.** The member which comprises the saddle **27** are of shell-form and become monocoque when secured into working position as by heli-arc welding.

## CONTROL

The vehicle X involves a single control means C for governing the gear ratio of the transmission Y and for applying actuation force to the brake. As shown, the bicycle has a front fork **31** comprised of a header with an upstanding tube **33** and spaced depending tubes **34** on which the front wheel **35** is journaled upon an anti-friction hub **36.** The upstanding tube **33** is journaled within the head **22** by means of spaced anti-friction bearings, the tube **33** projecting upwardly to carry a transverse handle bar **32** affixed thereto as shown. The front wheel has a tyred rim **37** that revolves forwardly beneath the header **33,** and it is in this area of the bicycle structure that the front brake is installed. Also, the bicycle has the rear forks **26** on which the rear wheel **28** is journaled upon an anti-friction hub **39.** The rear wheel has a tyred rim **37** that revolves forwardly within the upper extremity of forks **26,** and it is in this area of the bicycle structure that the rear brake is installed.

## TRANSMISSION

The single control means C for the vehicle X governs the gear ratio of the transmission Y for applying propelling force to the rear wheel **28.** The transmission Y is uniquely a constant mesh infinitely variable speed transmission adapted in this instance to bicycle requirements wherein there is a high torque low velocity input and a low torque high velocity output and involves the case **10** mounted to the saddle **27** and in which the crank shaft **11** is journaled upon the bearings **14** and **15** as above described. The oppositely projecting crank shaft **11** is revolved by opposite end crank arms **12** at high torque and low velocity, and there is a drive sprocket **51** coaxially rotatable over the shaft **11** and exposed at the exterior of the case **10** to transport a chain **52** that extends to a driven sprocket **53** affixed to the hub of the rear wheel **28.** The drive sprocket **51** operates at infinitely variable angular velocity and corresponding variable torque, as compared with the input shaft **11;** it being understood that said shaft **11** is operable at varied speeds and with the application of different torque values.

In accordance with this invention, the transmission Y comprises a constant mesh speed changer B and a variable speed feedback means F. The speed changer B is comprised of an input gear **55,** an output gear **56,** and a feedback gear **57.** The output gear **56** is characteristically a planet gear that cycles around the input sun gear **55** and within the feedback ring gear **57,** or the equivalent gearing. The variable speed feedback F is a means that governs the angular velocity of the feedback gear **57** and is characteristically a non-reversible gear engagement and the intermeshed engagement of all gear teeth is constant, the variable speed feedback velocity being applied in relation to the output velocity and controlled so as to determine the velocity of the output gear **56.** In carrying out this invention, the non-reversible gear engagement of the variable speed feedback F to the feedback gear **57** of the speed changer A is a worm and wheel engagement, wherein the worm gear **58** is operated at infinitely variable speed in governing the angular velocity of the worm wheel **59,** and controlling the angular velocity of gear **57** connected therewith so that the input-output velocities are accordingly added to or subtracted from as may be required.

In accordance with this invention, the transmission Y comprises first and second stages of gearing with a consequent substantial reduction of torque requirement on the variable speed feedback F. As shown, the first stage gearing involves a speed changer A and the second stage gearing involves the speed changer B. Like the speed changer B, speed changer A is comprised of an input gear **65**, an output gear **66**, and a stationary ring gear **67**. The input gear **65** is characteristically a planet gear that cycles around the output sun gear **66** and within the ring gear **67**, or the equivalent gearing. In the case illustrated where torque reduction is to be established at the feedback gear **57**, the primary ratio of gear change is obtained by step-up gearing in stage A and step-down gearing in stage B. For example, the ring gear **67** is three diameters of the output gear **66**, in which case the step-up ratio is **4** to **1** with a corresponding reduction in torque; while the ring gear **57** is two diameters of input gear **55**, in which case the step-down ratio is **3** to **1** with a correspondingly further reduction in torque and with the result that reduced force is required to control the angular velocity of the worm wheel **59** which drives the same at varied speeds. The **4** to **1** velocity increase will be divided by three when the ring gear **57** is stationary.

However, when the ring gear **57** is revolved with and at a velocity equal to that of the output gear **56**, there is no reduction in the primary **4** to **1** ratio. The worm gear **58** of feedback F can be employed to propel the worm wheel **59** and feedback gear **57** at any angular velocity slower or faster than that of the input gear **55**, thereby to subtract or add to the output ratio of output gear **66** relative to input gear **55**.

In carrying out this invention, the input planet gears **65** of speed changer A are journaled on bearing trunnions **60** disposed in a circumferential series projecting inwardly from a drive flange **61** on shaft **11** inward of and seated against the carrier bearing **14**. The ring gear **67** is fixedly captured in the housing of case **10** by the plate **17**, there being a retainer ring **62** embracing the trunnions **60** to hold the gears **65** in place. The output gear **66** of the first stage gearing is coupled directly to and preferably integral with the input gear **55** of the second stage gearing, these two gears being concentrically journaled by a common tubular hub over shaft **11** by needle bearings **63**. The output planet gears **56** of speed changer B are journaled on bearing trunnions **64** disposed in a circumferential series projecting from a drive flange **68** on tubular drive shaft **69** journaled on needle bearings **70** upon shaft **11**, there being a retainer ring **71** embracing the trunnions **64** to hold the gears **55** in place. The shaft **69** extends to the exterior of the housing wall **16**, being seated against carrier bearing **15** to driveably support the drive sprocket **51** at the exterior of case **10**. The feedback gear **57** is then journaled over the shaft **11** and tubular shaft **69** by means of a concentric hub **72** disposed between flange **68** and the bearing **15**. In practice, needle bearings are employed therebetween and an anti-friction axial thrust bearing **73** disposed against a drive gear **74** for means F projecting radially from the bearing **15** used as a positioning stop therefor. As will be apparent from the drawings, the aforementioned transmission elements are assembled into case **10** from the ends thereof and captured in working position by the plate **17** and a snap ring **75** respectively.

## ROTATIONAL FEEDBACK

In accordance with this invention, the variable speed feedback means F is provided to govern the angular velocity of the controlling feedback gear **57**. As shown, the gear **57** is integral with the worm wheel **59**, and the means F governs the angular velocity of worm gear **58** that is constantly meshed therewith. In practice, I employ a high velocity variable speed drive driven by the output velocity of the second stage gearing B and driving the worm wheel **59** through worm gear **58**. Various types of variable speed drives can be employed, the most practical of which is a frictional drive as shown. Accordingly, the feedback means F involves drive cone **75**, a driving cone **76**, a belt **77** operable therebetween, and a positioning means **78** for operational placement of said belt. The drive cone **75** is driven by drive gear **74**, while the driving cone **76** drives the worm wheel **59**.

The housing **19** of the transmission case **10** is provided with one or more openings to pass the drive and driving elements of the drive cone **75** and driving cone **76**, said cones being journaled on spaced and parallel shafts **80** and **81** extending laterally of the case in a plane normal to the housing of said case. The shafts **80** and **81** are carried by anti-friction ball bearings to extend between the side wall of the housing **19** and a header **82** spaced therefrom by a post **83** disposed intermediate the two cones. A drive gear **74** is fixed to drive shaft **80** within the housing **19** and is a bevel gear constantly meshed with the gear **74**, to have a speed increase of **1** to **5**. A driving gear **84** is fixed to driving shaft **81** within the housing **19** and turns a feedback shaft **85** through a speed increasing gear **86**. Although the driving of worm gear **58** can be direct from driving shaft **81**, a speed increase of **1** to **2** is desired in the embodiment shown, wherein the worm to wheel ratio is **20** to **1** (a non-reversible ratio).

Referring now to the variable function of the cones **75** and **76**, they are inversely tapered cones between which the belt **77** frictionally transmits angular velocity dependent upon the radius of engagement. Assuming the engaged radii of the two cones to be the same, the belt **77** will transmit equal angular velocity through both. However, as the engaged radius of one is increased and the other decreased, the angular velocity of the latter is increased relative to the former, and vice versa. In the embodiment shown, the drive cone is larger than the driving cone, proportioned to operate the latter between a speed reduction of 1½ to 1 to a speed increase of 1 to 2. The positioning means **78** for operational placement of the belt **77** is shown as a fork **87** embracing the drive cone and having spaced fingers **88** projecting inwardly from each leg of the fork to guide the oppositely running portions of the belt. Fork **87** is pivoted at its top end, so that its free swinging ends move between the two cones. In practice, a return spring **89** retracts the free end of the fork toward the speed increasing ends of the cones while a pull cable **90** extending to the control means C is fixed thereto to draw the free ends of the fork toward the speed decreasing ends of the cones. The cover **18** attached to post **83** encloses the feedback means F and supports the anchor and guide **92** for the pull cable **90**. It will be seen that the angular velocity of the feedback shaft **85** varies infinitely according to placement of the belt **77** by frictionally engaging the inversely tapered cones.

BRAKE-TRANSMISSION CONTROL

Referring now to the control means C for applying the brakes and for conditioning the ratio determining element of the transmission feedback means F, the control means C is a handle **100** that is manually operable to simultaneously actuate the brakes and condition the transmission; being compressible to effect the former and rotatable to effect the latter. The handle **100** is carried by the handle bar **32** to depend from the conventional grip portion **101** of said handle bar, there being a base **102** attached to the grip by a clamp **103** so as to project laterally of and preferably forwardly from the handle bar and its conventional (race) configuration; downwardly and rearwardly turned. A feature of the control means is the swivel **104** disposed on the laterally extended axis of the base and to which the handle **100** is pivoted by a transverse pin **105.** The handle **100** is a first class lever having a pull pin **106** spaced from pivot pin **105** and to which the actuation cable **50** of brake Z is affixed for movement through a sheath seated in the swivel; the usual manner of pulling such a brake cable. The swivel **104** is rotatably captured to the base **102** by a center shaft **107,** there being a friction washer **108** disposed between the swivel and base, and a spring washer **109** cpatured by a nut so as to apply pressure thereto. It will be observed that the base **102** and swivel **104** are tubular and telescopically related for rotatable stability, there being a tangential opening **110** through the base with a seat for the sheath of pull cable **90.** Accordingly, there is a peripheral channel **111** in the swivel **104,** and aligned with the opening **110,** to accommodate the pull cable **90** as it extends to an anchor point within the swivel. Thus, the swivel draws in the cable as it is turned counter clockwise (as shown) and lets out the cable as it is turned clockwise, the former to increase speed of the feedback means F and the latter to decrease the same. It will be seen that independent control of the brakes and transmission Y is effected with the control means C, while the bicycle rider has but the one control member to be concerned with, and such that the braking function is ever present when the gear ratio changes are to be made.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art.

I claim:

**1.** A low velocity high torque infinitely variable speed constant mesh transmission for bicycles and the like, including; a case with a crank shaft extending therethrough and with its opposite ends projecting from the case, a first stage speed changer comprising, a stationary ring gear and an input planet gear journaled on a carrier driven by the crank shaft and in constant mesh with said ring gear, and an output sun gear in constant mesh with said planet gear to be driven at increased angular velocity thereby; and a second stage speed changer comprising, an input sun gear driven by the first stage sun gear and a planet gear journaled on an output carrier rotatable over the crank shaft and in constant mesh with said second stage sun gear, and a rotatable ring gear in constant mesh with said planet gear; and an infinitely variable speed feedback drive means driven by the output carrier of the second stage and controlling the angular velocity of the rotatable second stage ring gear to effect a commensurate velocity change between the crank shaft and the output carrier.

**2.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1** wherein the feedback drive means is a non-reversible gear engagement with the second stage ring gear.

**3.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feedback is a high velocity drive rotating the second stage ring gear to reduce velocity in said second stage speed changer.

**4.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feedback comprises inversely tapered cones with an axially positioned belt engaged therebetween, one cone driven by the output carrier of the second stage speed changer and the other cone driving the rotatable ring gear of the second stage speed changer.

**5.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feedback comprises inversely tapered cones with an axially positioned belt engaged therebetween, one cone driven by the output carrier of the second stage speed changer and the other cone driving the rotatable ring gear of the second stage speed changer through a non-reversible worm and wheel drive.

**6.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the case has spaced end walls with carrier bearings through which the crank shaft projects with oppositely exposed ends.

**7.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the case has spaced end walls with carrier bearings through which the crank shaft and second stage carrier extend outside the case with the opposite ends of the crank shaft driveably exposed.

**8.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the case has spaced end walls with carrier bearings through which the crank shaft and second stage carrier extend outside the case with a drive sprocket exposed on the carrier and with opposite ends of the crank shaft driveably exposed.

**9.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feed comprises a right angle gear driven from the second stage carrier and on an axis parallel to feed back gearing into the second stage ring gear.

**10.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feedback comprises inversely tapered cones journaled on spaced parallel axes disposed normal to the crank shaft axis, an axially positioned belt engaged between the cones, one cone driven by the output carrier of the second stage speed changer and the other cone driving the rotatable ring gear of the second stage speed changer.

**11.** The two-stage infinitely variable speed constant mesh transmission as set forth in claim **1,** wherein the infinitely variable feedback comprises inversely tapered cones journaled on spaced parallel axes disposed normal to the crank shaft axis, an axially positioned belt engaged between the cones, one cone driven by

the output carrier of the second stage speed changer and the other cone driving the rotatable ring gear of the second stage speed changer through a non-reversible worm and wheel drive.

* * * * *